

November 3, 2004

Mr. Gregg R. Overbeck
Senior Vice President, Nuclear
Arizona Public Service Company
P. O. Box 52034
Phoenix, AZ 85072-2034

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1 AND 3 - RELIEF
REQUEST NO. 28 RE: TEMPER BEAD WELDING PROCESS FOR
PRESSURIZER HEATER SLEEVES (TAC NOS. MC3553 AND MC3555)

Dear Mr. Overbeck:

By letter dated June 15, 2004, as supplemented by letter dated August 24, 2004, Arizona Public Service Company submitted Relief Request No. 28, requesting relief from certain American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) required repair and inspection criteria at Palo Verde Nuclear Generating Station (PVNGS), Units 1 and 3. In lieu of ASME Code requirements, the licensee proposed an alternative temper bead welding process to repair the pressurizer heater sleeves. The relief is requested for the second 10-year inservice inspection (ISI) interval at PVNGS, Units 1 and 3.

Based on the enclosed Safety Evaluation, the NRC staff concludes that the proposed alternatives provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternatives at the PVNGS, Units 1 and 3 for the second 10-year ISI interval. All other requirements of the ASME Code, Section III and XI for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Sincerely,

/RA/

Robert A. Gramm, Chief, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-528 and STN 50-530

Enclosure: Safety Evaluation

cc w/encl: See next page

Palo Verde Generating Station, Units 1, 2, and 3

cc:

Mr. Steve Olea
Arizona Corporation Commission
1200 W. Washington Street
Phoenix, AZ 85007

Douglas Kent Porter
Senior Counsel
Southern California Edison Company
Law Department, Generation Resources
P.O. Box 800
Rosemead, CA 91770

Senior Resident Inspector
U.S. Nuclear Regulatory Commission
P. O. Box 40
Buckeye, AZ 85326

Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
Harris Tower & Pavillion
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064

Chairman
Maricopa County Board of Supervisors
301 W. Jefferson, 10th Floor
Phoenix, AZ 85003

Mr. Aubrey V. Godwin, Director
Arizona Radiation Regulatory Agency
4814 South 40 Street
Phoenix, AZ 85040

Mr. M. Dwayne Carnes, Director
Regulatory Affairs/Nuclear Assurance
Palo Verde Nuclear Generating Station
P.O. Box 52034
Phoenix, AZ 85072-2034

Mr. Hector R. Puente
Vice President, Power Generation
El Paso Electric Company
310 E. Palm Lane, Suite 310
Phoenix, AZ 85004

Mr. John Taylor
Public Service Company of New Mexico
2401 Aztec NE, MS Z110
Albuquerque, NM 87107-4224

Ms. Cheryl Adams
Southern California Edison Company
5000 Pacific Coast Hwy Bldg DIN
San Clemente, CA 92672

Mr. Robert Henry
Salt River Project
6504 East Thomas Road
Scottsdale, AZ 85251

Mr. Jeffrey T. Weikert
Assistant General Counsel
El Paso Electric Company
Mail Location 167
123 W. Mills
El Paso, TX 79901

Mr. John Schumann
Los Angeles Department of Water & Power
Southern California Public Power Authority
P.O. Box 51111, Room 1255-C
Los Angeles, CA 90051-0100

Brian Almon
Public Utility Commission
William B. Travis Building
P. O. Box 13326
1701 North Congress Avenue
Austin, TX 78701-3326

November 3, 2004

Mr. Gregg R. Overbeck
Senior Vice President, Nuclear
Arizona Public Service Company
P. O. Box 52034
Phoenix, AZ 85072-2034

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1 AND 3 - RELIEF
REQUEST NO. 28 RE: TEMPER BEAD WELDING PROCESS FOR
PRESSURIZER HEATER SLEEVES (TAC NOS. MC3553 AND MC3555)

Dear Mr. Overbeck:

By letter dated June 15, 2004, as supplemented by letter dated August 24, 2004, Arizona Public Service Company submitted Relief Request No. 28, requesting relief from certain American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) required repair and inspection criteria at Palo Verde Nuclear Generating Station (PVNGS), Units 1 and 3. In lieu of ASME Code requirements, the licensee proposed an alternative temper bead welding process to repair the pressurizer heater sleeves. The relief is requested for the second 10-year inservice inspection (ISI) interval at PVNGS, Units 1 and 3.

Based on the enclosed Safety Evaluation, the NRC staff concludes that the proposed alternatives provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternatives at the PVNGS, Units 1 and 3 for the second 10-year ISI interval. All other requirements of the ASME Code, Section III and XI for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Sincerely,

/RA/

Robert Gramm, Chief, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-528 and STN 50-530

Enclosure: Safety Evaluation

cc w/encl: See next page

DISTRIBUTION:

PUBLIC	RidsNrrPDIVHBerkow	RidsNrrPMMFields
PDIV-2 r/f	RidsAcrsAcnwMailCenter	RidsRgn4MailCenter (TPruett)
GHill (6)	RidsNrrLAEPeyton	RidsOgcRp
TChan	DNaujock	MMitchell, EDO
*SE Memo		

ACCESSION NO: ML043010425

NRR-106

OFFICE	PDIV-2/PM	PDIV-2/LA	EMCB*	OGC-NLO	PDIV-2/SC
NAME	MFields:mp	DBaxley	TChan	MLemoncelli	RGramm
DATE	10-29-04	10/29/04	9/29/04	10/21/04	11/3/04

OFFICIAL RECORD COPY

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

INSERVICE INSPECTION PROGRAM RELIEF REQUEST NO. 28

TEMPER BEAD WELDING PROCESS FOR PRESSURIZER HEATER SLEEVES

ARIZONA PUBLIC SERVICE COMPANY, ET AL.

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1 AND 3

DOCKET NOS. STN 50-528 AND STN 50-530

1.0 INTRODUCTION

By letter dated June 15, 2004, as supplemented by letter dated August 24, 2004, Arizona Public Service Company (APS or the licensee) requested relief from certain American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) required repair and inspection criteria at the Palo Verde Nuclear Generating Station (PVNGS), Units 1 and 3. In lieu of ASME Code requirements, the licensee proposed an alternative temper bead welding process to repair the pressurizer heater sleeves. The relief is requested for the second 10-year inservice inspection (ISI) interval at PVNGS, Units 1 and 3.

2.0 REGULATORY EVALUATION

The ISI of ASME Code Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME Code and applicable edition and addenda as required by 50.55a(g) of Title 10 of the *Code of Federal Regulations* (10 CFR), except where specific written relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). The Regulation at 10 CFR 50.55a(a)(3) states, in part, that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the licensee demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to

the limitations and modifications listed therein. The ISI Code of record for PVNGS, Units 1 and 3 is the 1992 Edition with 1992 Addenda of Section XI of the ASME Code. The second 10-year interval for Unit 1 began July 18, 1998, and ends July 17, 2008, and for Unit 3 began January 11, 1998, and ends January 10, 2008.

2.1 Components for which Relief is Requested

PVNGS, Units 1 and 3 pressurizer heater sleeves.

2.2 Code Requirements for which Relief is Requested

As stated by the licensee in Section III of the enclosure to its letter dated June 15, 2004:

Subarticle IWA-4170(b) of ASME Section XI, 1992 Edition, 1992 Addenda states: "Repairs and installation of replacement items shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. [Later editions and Addenda of the Construction Code or of Section III, either in their entirety or portions thereof, and Code Cases may be used.] If repair welding cannot be performed in accordance with these requirements, the applicable requirements of IWA-4200, IWA-4400, or IWA-4500 may be used."

IWA-4500 of ASME Section XI establishes alternative repair welding methods for performing temper bead welding. According to IWA-4500(a), "Repairs to base materials and welds identified in IWA-4510, IWA-4520, and IWA-4530 may be made by welding without the specified postweld heat treatment requirements of the Construction Code or Section III, provided the requirements of IWA-4500(a) through (e) and IWA-4510, IWA-4520, or IWA-4530, as applicable, are met."

IWA-4530 applies to dissimilar materials such as welds that join P-Number 43-nickel alloy[s] to P-Number 3 low alloy steels. According to IWA-4530, "Repairs to welds that join P-No. 8 or P-No. 43 material to P-Nos. 1, 3, 12A, 12B, and 12C material may be made without the specified postweld heat treatment, provided the requirements of IWA-4530 through IWA-4533 are met." [Repairs are limited to those along the fusion line of a nonferritic weld to ferritic base material where 1/8-inch or less of nonferritic weld deposit exists above the original fusion line after defect removal.]

[Temper bead repairs of pressurizer heater sleeve nozzles are performed in accordance with IWA-4500 and IWA-4530 whenever the repair cavity is within 1/8-inch of the ferritic base materials.] When the GTAW [Gas Tungsten Arc Welding] process is used in accordance with IWA-4500 and IWA-4530, then temper bead welding is performed as follows:

- Only the automatic or machine GTAW process using cold wire feed can be used. Manual GTAW cannot be used.

- A minimum preheat temperature of 300EF is established and maintained throughout the welding process. Interpass temperature cannot exceed 450EF.
- The weld cavity is buttered with at least six (6) layers of weld metal.
- Heat input of the initial six layers is controlled to within +/-10% of that used for the first six layers during procedure qualification testing.
- After the first six weld layers, repair welding is completed with a heat input that is equal to or less than that used in the procedure qualification for weld layers seven and beyond.
- Upon completion of welding, a postweld soak or hydrogen bake-out at 300EF (minimum) for a minimum of 4 hours is required.
- Preheat, interpass, and postweld soak temperatures are monitored using thermocouples and recording instruments.
- The repair weld and preheated band are examined in accordance with IWA-4533 after the completed weld has been at ambient temperature for 48 hours.

2.3 Licensee's Proposed Alternative to Code

As stated by the licensee in Section IV of the enclosure to its letter dated June 15, 2004:

Pursuant to 10 CFR 50.55a(a)(3)(i), APS proposes alternatives to the GTAW-machine temper bead welding requirements of IWA-4500 and IWA-4530 of ASME Section XI. Specifically, APS proposes to perform ambient temperature temper bead welding in accordance with Attachment 1, "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique," [to the June 15, 2004, letter] as an alternative to IWA-4500 and IWA 4530 [(i.e., Relief Request No. 28)].

APS has reviewed the proposed ambient temperature temper bead welding techniques of Attachment 1[to the June 15, 2004 letter,] against the GTAW-machine temper bead welding requirements of IWA-4500 and IWA-4530. This review was performed to identify differences between Attachment 1 [to the June 15, 2004, letter] and IWA-4500 and IWA-4530. Based upon this review, APS proposes alternatives to the following ASME Section XI requirements of IWA-4500 and IWA-4530:

1. IWA-4500(a) specifies that repairs to base materials and welds identified in IWA-4530 may be performed without the specified postweld heat treatment of the construction code or ASME Section III provided the requirements of IWA-4500 and IWA-4530 are met. IWA-4530 includes temper bead requirements applicable to the SMAW [Shielded Metal Arc Welding] and the

machine or automatic GTAW processes [using preheat and post bake operations]. As an alternative, APS proposes to perform temper bead weld repairs using the ambient temperature temper bead technique [without any preheat and post bake operations] described in Attachment 1 [to the June 15, 2004, letter]. Only the machine or automatic GTAW process can be used when performing ambient temperature temper bead welding in accordance with Attachment 1 [to the June 15, 2004 letter].

2. IWA-4500(d)(2) specifies that if repair welding is to be performed where physical obstructions impair the welder's ability to perform, the welder shall also demonstrate the ability to deposit sound weld metal in the [required] positions, using the same parameters and simulated physical obstructions as are involved in the repair. This limited accessibility demonstration applies when manual temper bead welding is performed using the SMAW process. It does not apply to "welding operators" who perform machine or automatic GTAW welding from a remote location. This distinction is clearly made in IWA-4500 and IWA-4530. Because the proposed ambient temperature temper bead technique described in Attachment 1 [of the June 15, 2004, letter] utilizes a machine GTAW welding process, limited access demonstrations of "welding operators" are not required. Therefore, the requirement of IWA-4500(d)(2) does not apply.
3. IWA-4500(e)(2) specifies that the weld area plus a band around the repair area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 300EF for the GTAW process during welding; maximum interpass temperature shall be 450EF. As an alternative, APS proposes that the weld area plus a band around the repair area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 50EF for the GTAW process during welding; maximum interpass temperature shall be 350EF regardless of the interpass temperature during qualifications.
4. IWA-4500(e)(2) specifies that thermocouples and recording instruments shall be used to monitor process temperatures, and that thermocouple attachment and removal shall be performed in accordance with ASME Section III. APS will not use any thermocouples or recording instrument since there is no elevated preheat; because of the large heat sink interpass temperature does not approach anywhere near 350EF.
5. IWA-4532.1 establishes procedure technique requirements that apply when using the SMAW process. Because the proposed ambient temperature temper bead technique of Attachment 1 [to the June 15, 2004, letter] utilizes the machine or automatic GTAW welding process, the SMAW temper bead technique requirements of paragraph IWA-4532.1 do not apply.
6. IWA-4532.2(c) specifies that the repair cavity shall be buttered with the first six layers of weld metal in which the heat input of each layer is controlled to within +/-10% of that used in the procedure qualification test, and heat input control for subsequent layers shall be deposited with a heat input equal to or less than that

used for layers beyond the sixth in the procedure qualification. As an alternative, APS proposes to deposit the weld area with a minimum of three layers of weld metal to obtain a minimum thickness of 1/8-inch. The heat input of each weld layer in the 1/8-inch thick weld section shall be controlled to within +/-10% of that used in the procedure qualification test. The heat input for subsequent weld layers shall not exceed the heat input used for layers beyond the 1/8-inch thick section (first three weld layers) in the procedure qualification.

7. IWA-4532.2(c) specifies that the completed weld shall have at least one layer of weld reinforcement deposited and then this reinforcement shall be removed by mechanical means. As an alternative, APS's proposed ambient temperature temper bead technique does not include a reinforcement layer.
8. IWA-4532.2(d) specifies that, after at least 3/16-inch of weld metal has been deposited, the weld area shall be maintained at a temperature of 300EF (minimum) for a minimum of four (4) hours (for P-No. 3 materials). As an alternative, APS's proposed ambient temperature temper bead technique does not include a postweld soak.
9. IWA-4532.2(e) specifies that after depositing at least 3/16-inch of weld metal and performing a postweld soak at a minimum temperature of 300EF, the balance of welding may be performed at an interpass temperature of 350EF. As an alternative, APS proposes that an interpass temperature of 350EF may be used after depositing at least 1/8-inch of weld metal without a postweld soak.
10. IWA-4533 specifies the following examinations shall be performed after the completed repair weld has been at ambient temperature for at least 48 hours: (a) the repair weld and preheated band shall be examined by the liquid penetrant method; (b) the repaired region shall be examined by the radiographic method, and if practical, (c) by the ultrasonic method. APS will perform the liquid penetrant examination of the completed repair weld. As an alternative to the radiographic examination of IWA-4533, APS proposes ultrasonic examination of the repair weld.

2.4 Licensee's Basis for Relief

As stated by the licensee in Section V of the enclosure to its letter dated June 15, 2004:

The pressurizer head is manufactured from P-Number 3, Group 3 low alloy steel. If repairs are performed in accordance with ASME Section III, APS would have two options: (1) perform a weld repair that includes a postweld heat treatment at 1100EF - 1250EF in accordance with NB-4622.1; or (2) perform a temper bead repair using the SMAW process in accordance with NB-4622.11. Each option is discussed below.

1. Postweld heat treatment (PWHT) of the pressurizer head is an impractical option that could cause ovalization and misalignment of heater sleeves, permanently damaging the pressurizer lower head including the heater

support assembly. ASME Section III NB-4600 requires PWHT to be performed at 1100EF to 1250EF.

2. NB-4622.11 provides temper bead rules for repair welding of dissimilar materials using the SMAW process. Because NB-4622.11 does not include temper bead rules for the machine or automatic GTAW process, a manual SMAW temper bead process must be used. However, a manual SMAW temper bead repair is not a desirable option due to radiological considerations. First, resistant heating blankets, thermocouples, and insulation must be installed. Secondly, the manual SMAW temper bead welding process is a time and dose intensive process. Each weld layer is manually deposited in a high dose and high temperature (350EF) environment. The manual SMAW temper bead process of NB-4622.11 also requires that the weld crown of the first weld layer be mechanically removed by grinding. Upon completing repair welding, resistant heating blankets, thermocouples, and insulation must be removed. Thermocouples and heating blanket-mounting pins must be removed by grinding. The ground areas must be subsequently examined by the magnetic particle or liquid penetrant examination.

APS is not requesting an alternative to NB-6422.11; rather, this request proposes an alternative to IWA-4500 and IWA-4530. Owners are allowed by ASME Section XI IWA-4170(b) and IWA-4500(a) to perform temper bead repairs of dissimilar materials. IWA-4170(b) and IWA-4500(a) provide requirements and controls for performing such repairs.

IWA-4500 and IWA-4530 of ASME Section XI establish requirements for performing temper bead welding of "dissimilar materials." According to IWA-4530, either the automatic or machine GTAW process or SMAW process may be used. When using the machine GTAW process, a minimum preheat temperature of 300EF must be established and maintained throughout the welding process while the interpass temperature is limited to 450EF. Upon completion of welding, a postweld soak is performed at 300EF (minimum) for a minimum of 4 hours.

The IWA-4500 and IWA-4530 temper bead welding process is a time and dose intensive process. Resistant heating blankets are typically attached to the pressurizer head using a capacitor discharge stud welding process. Thermocouples must also be attached to the pressurizer head using a capacitor discharge welding process to monitor pre-heat, interpass, and postweld soak temperatures. Prior to heat-up, thermal insulation is also installed. Upon completion of repair welding (including the postweld soak), the insulation, heating blankets, studs, and thermocouples must be removed from the pressurizer head. Thermocouples and stud welds are removed by grinding. Ground removal areas are subsequently examined by the liquid penetrant or magnetic particle method. A significant reduction in dose could be realized by utilizing an ambient temperature temper bead process, as explained in the background information under "Radiation Exposure Reduction." Therefore, APS proposes an alternative welding technique based on methodology of code case N-638.

A. Evaluation of the Ambient Temperature Temper Bead Technique

Research by the Electric Power Research Institute (EPRI) and other organizations on the use of an ambient temperature temper bead technique using the machine GTAW process is documented in EPRI Report GC-111050 ["Ambient Temperature Preheat for Machine GTAW Temper Bead Applications," dated November 1998]. According to the EPRI report, repair welds performed with an ambient temperature temper bead procedure utilizing the machine GTAW welding process exhibit mechanical properties that are equivalent [to] or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process.

The effects of the ambient temperature temper bead welding process of Attachment 1 on mechanical properties of repair welds, hydrogen cracking, and [cold] restraint cracking are addressed below.

1. Mechanical Properties

The principal reason to preheat a component prior to repair welding is to minimize the potential for cold cracking. The two cold cracking mechanisms are hydrogen cracking and restraint cracking [due to a high degree of restraint]. Both of these mechanisms occur at ambient temperature. Preheating slows down the cooling rate resulting in a ductile, less brittle microstructure thereby lowering susceptibility to cold cracking. Preheat also increases the diffusion rate of monatomic hydrogen that may have been trapped in the weld during solidification. As an alternative to preheat, the ambient temperature temper bead welding process utilizes the tempering action of the welding procedure to produce tough and ductile microstructures. Because precision bead placement and heat input control [are] characteristics of the machine GTAW process, effective tempering of the weld heat affected zones is possible without the application of preheat. The ambient temperature temper bead procedure is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered heat affected zone such that the desired degree of carbide precipitation (tempering) is achieved. The resulting microstructure is very tough and ductile.

The IWA-4530 temper bead process also includes a postweld soak requirement. Performed at 300EF for 4 hours for P-Number 3 base materials, this postweld soak assists diffusion of any remaining hydrogen from the repair weld. As such, the postweld soak is a hydrogen bake-out and not a post weld heat treatment as defined by the ASME Code. At 300EF, the post weld soak does not stress relieve, temper, or alter the mechanical properties of the weldment in any manner.

Section 2.1 of Attachment 1 [to the letter dated June 15, 2004,] establishes detailed welding procedure qualification requirements for base materials, filler metals, restraint, impact properties, and other procedure variables. The qualification requirements . . . provide assurance that the mechanical properties of repaired welds will be equivalent or superior to those of the surrounding base material.

2. Hydrogen Cracking

Hydrogen cracking is a form of cold cracking. It is produced by the action of internal tensile stresses acting on low toughness heat affected zones. The internal stresses are produced from localized build-up of monatomic hydrogen. Monatomic hydrogen forms when moisture or hydrocarbons interact with the welding arc and molten weld pool. The monatomic hydrogen can be entrapped during weld solidification and tends to migrate to transformation boundaries or other microstructure defect locations. As concentrations build, the monatomic hydrogen will recombine to form molecular hydrogen - thus generating localized internal stresses at these internal defect locations. If these stresses exceed the fracture toughness of the material, hydrogen induced cracking will occur. This form of cracking requires the presence of hydrogen and low toughness materials. It is manifested by intergranular cracking of susceptible materials and normally occurs within 48 hours of welding.

IWA-4500 establishes elevated preheat and postweld soak requirements. The elevated pre-heat temperature of 300EF increases the diffusion rate of hydrogen from the weld. The postweld soak at 300EF was also established to bake-out or facilitate diffusion of any remaining hydrogen from the weldment. However, while hydrogen cracking is a concern for SMAW, which uses flux covered electrodes, the potential for hydrogen cracking is significantly reduced when using the machine GTAW welding process.

The machine GTAW welding process is inherently free of hydrogen. Unlike the SMAW process, GTAW welding filler metals do not rely on flux coverings that are susceptible to moisture absorption from the environment. The GTAW process utilizes dry inert shielding gases that cover the molten weld pool from oxidizing atmospheres. Any moisture on the surface of the component being welded will be vaporized ahead of the welding torch. The vapor is prevented from being mixed with the molten weld pool by the inert shielding gas that blows the vapor away before it can be mixed. Furthermore, modern filler metal manufacturers produce weld wires that have very low residual hydrogen. This is important because filler metals and base materials are the most realistic sources of hydrogen for automatic or machine GTAW temper bead welding. Therefore, the potential for hydrogen induced cracking is greatly reduced by using [the] machine GTAW process.

3. [Cold] Restraint Cracking

Restraint cracking generally occurs during cooling at temperatures approaching ambient temperature. As stresses build under a high degree of restraint, cracking may occur at defect locations. Brittle microstructures with low ductility are subject to cold restraint cracking [due to a high degree of restraint]. However, the ambient temperature temper bead process is designed to provide a sufficient heat inventory so as to produce the desired tempering for high toughness. Because the machine GTAW temper bead process provides precision bead placement and control of heat, the toughness and ductility of the heat-affected zone is typically superior to the base material. Therefore, the resulting structure is tempered to produce toughness that is resistant to cold cracking.

3.0 EVALUATION

According to IWA-4500(a), repairs may be performed to dissimilar base materials and welds without the specified postweld heat treatment of ASME Section III provided the requirements of IWA-4500 and IWA-4530 are met. The temper bead rules of IWA-4500 and IWA-4530 apply to the dissimilar materials P-No. 43 and P-No. 3 base materials welded together with F-No. 43 filler metals. When using the GTAW-machine process, IWA-4500 and IWA-4530 temper bead process is based on an elevated preheat temperature of 300EF, a maximum interpass temperature of 450EF, and a postweld soak of 300EF. The licensee's alternative proposes to weld P-No. 43 to P-No. 3 base metals with F-No. 43 filler metals at ambient temperature, using a temper bead technique which only utilizes the GTAW-machine or GTAW-automatic process.

According to IWA-4500(e)(2), the weld area plus a band around the repair area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be preheated and maintained at a minimum temperature of 300EF for the GTAW process during welding while the maximum interpass temperature is limited to 450EF. Likewise, the proposed alternative ambient temperature temper bead technique also establishes a preheat band of at least 1½ times the component thickness or 5 inches, whichever is less. However, the ambient temperature temper bead technique requires a minimum preheat temperature of 50EF, a maximum interpass temperature of 150EF for the first three layers, and a maximum interpass temperature of 350EF for the balance of welding. This is suitable because the heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop an acceptable degree of tempering in the underlying heat affected zone (HAZ). This is further demonstrated in EPRI report GC-111050, wherein repair welds performed with an ambient temperature temper bead procedure utilizing the machine GTAW welding process exhibit mechanical properties equivalent to or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process. Based on this data, the interpass temperature specified in the licensee's proposed alternative will provide an acceptable level of quality and safety.

Per IWA-4500(e)(2), thermocouples and recording instruments shall also be used to monitor process temperatures. As an alternative to IWA-4500(e)(2), APS proposes to monitor preheat and interpass temperatures using an infrared thermometer. Infrared thermometers are hand-held devices that can be used to monitor process temperature from a remote location. The preheat temperature will be 50EF (minimum) prior to depositing the first weld layer. For the first three layers, the interpass temperatures will be at least 50EF but less than 150EF. The interpass temperature of each remaining layer will be at least 50EF but less than 350EF prior to depositing the subsequent weld layers. The preheat temperature required for this welding is 50EF. This temperature is to be maintained on a weldment inside a building which normally is above this temperature, providing an acceptable level of quality and safety for this preheat measurement alternate method. The maximum interpass temperatures required for the subject welds (150EF for the first three layers, and a maximum interpass temperature of 350EF for the balance of welding), can also be measured with this type of device. The large mass of the pressurizer head coupled with the low heat input GTAW process will keep the interpass temperature from approaching the maximum interpass temperatures, making it unlikely that the welds will ever exceed these temperatures. In addition, the alternate temperature measurement methods proposed will maintain close control on these temperatures. Based on this reasoning, the licensee's proposed alternative to monitor process temperatures will provide an acceptable level of quality and safety.

According to IWA-4532.2(c), the repair cavity shall be buttered with six layers of weld metal in which the heat input of each layer is controlled to within +/-10% of that used in the procedure qualification test, and heat input control for subsequent layers shall be deposited with a heat input equal to or less than that used for layers beyond the sixth in the procedure qualification. As an alternative to IWA-4532.2, APS proposes to butter the repair cavity or weld area with at least three layers of weld metal to obtain a minimum butter thickness of 1/8-inch. The heat input of each layer in the 1/8-inch thick buttered section shall be controlled to within +/-10% of that used in the procedure qualification test. The heat input for subsequent weld layers shall not exceed the heat input used for layers beyond the 1/8-inch thick buttered section (first three weld layers) in the procedure qualification. The alternative ambient temperature temper bead technique uses a machine GTAW process which is a low heat input process. Subsequent GTAW weld layers introduce heat into the HAZ produced by the initial weld layer. The heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop a correct degree of tempering in the underlying HAZ. When welding dissimilar materials with nonferritic weld metal, the area requiring tempering is limited to the weld HAZ of the ferritic base material along the ferritic fusion line. After buttering the ferritic base material with at least 1/8-inch of weld metal (first 3 weld layers), subsequent weld layers should not provide any additional tempering to the weld HAZ in the ferritic base material. Therefore, less restrictive heat input controls are adequate after depositing the 1/8-inch thick buttered section. The NRC staff notes that IWA-4530 does not require temper bead welding except "where 1/8-inch or less of nonferritic weld deposit exists above the original fusion line after defect removal." Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in weld HAZ were greater than those of the unaffected base material. Therefore, the proposed heat input controls of alternative provides an appropriate level of tempering and the proposed alternate provides an acceptable level of quality and safety.

According to IWA-4532.2(c), at least one layer of weld reinforcement shall be deposited on the completed weld with this reinforcement being subsequently removed by mechanical means. The alternative reinforcement layer is not removed. A reinforcement layer is required when a weld repair is performed to a ferritic base material or ferritic weld using a ferritic weld metal. The weld reinforcement layer is deposited to temper the last layer of untempered weld metal of the completed repair weld. However, when repairs are performed to dissimilar materials using nonferritic weld metal, a weld reinforcement layer is not required because nonferritic weld metal does not require tempering. When performing a dissimilar material weld with a nonferritic filler metal, the only location requiring tempering is the weld HAZ in the ferritic base material along the weld fusion line. However, the three weld layers of the 1/8-inch thick butter section are designed to provide the required tempering to the weld HAZ in the ferritic base material. Therefore, a weld reinforcement layer is not required. This position is supported by ASME Code Case N-638 which only requires the deposition and removal of a reinforcement layer when performing repair welds on similar (ferritic) materials. ASME Code Case N-638 is endorsed in Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability." Repair welds on dissimilar materials are exempt from the removal of the reinforcement. Non-ferritic filler metals, such as the F-No. 43 filler metal, do not undergo a phase change at elevated temperature and, therefore, do not require a PWHT. Since the last layer of weld metal is a non-ferritic metal being deposited over two previous non-ferritic weld filler metal layers, the need for a tempering layer and its removal is unnecessary. Therefore, deletion of this requirement is acceptable.

According to IWA-4532.2(d), the weld area shall be maintained at a temperature of 300EF (minimum) for a minimum of 4 hours (for P-No. 3 materials) after at least 3/16-inch of weld metal has been deposited. According to IWA-4532.2(e), after depositing at least 3/16-inch of weld metal and performing a postweld soak at 300EF (minimum), the balance of welding may be performed at an interpass temperature of 350EF. In the proposed alternative in Attachment 1 to the June 15, 2004, letter, a postweld soak is not required and APS also proposes that an interpass temperature of 350EF may be used after depositing at least 1/8-inch of weld metal without a postweld soak. The proposed ambient temperature temper bead welding technique is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered HAZ and the desired degree of tempering is achieved. The use of the automatic or machine GTAW process utilized for temper bead welding allows for precise control of heat input, bead placement, and bead size and contour. The resulting microstructure is tough and ductile.

Based on Charpy V-notch testing of the procedure qualification test coupon, impact properties in the weld HAZ were greater than those of the unaffected base material. Therefore, the proposed heat input controls provide an appropriate level of tempering. The use of a GTAW temper bead welding technique to avoid the need for postweld heat treatment is based on research that has been performed by EPRI and other organizations. The research demonstrates that carefully controlled heat input and bead placement allows subsequent welding passes to relieve stress and temper the HAZ of the base material and preceding weld passes. Data presented in the EPRI report show the results of acceptable procedure qualifications performed with 300EF preheats and 500EF preheats, as well as with no preheat and postheat. In addition, many acceptable

procedure qualification records and welding procedure specifications presently exist which have been utilized to perform numerous successful repairs which indicate that the use of the ambient GTAW temper bead welding technique is an acceptable approach. From this data, it can be shown that adequate toughness can be achieved in base metal and HAZs with the use of a GTAW temper bead welding technique. The GTAW temper bead process has been shown effective by research and successful procedure qualifications. In addition, many successful repairs have been performed since the technique was developed. Therefore, the proposed ambient temperature temper bead welding technique will provide an acceptable level of quality and safety .

According to IWA-4533, repair welds shall be volumetrically examined by the radiographic method, and if practical, by the ultrasonic method after the completed repair weld has been at ambient temperature for at least 48 hours. The configuration and location of the weld in the pressurizer is not amenable to RT. The sleeve-to-pressurizer welds are not accessible from two directions for film and source placement. Moreover, the results of an RT would be questionable because of density changes between the base and weld metal, and residual radiation from the base metal would render the film image inconclusive. In lieu of RT, the licensee proposed using UT, which is used to identify features that reflect sound waves. The degree of reflection depends largely on the physical state of matter on the opposite side of the reflective surface and, to a lesser extent, on specific physical properties of the matter (density). For example, sound waves are almost completely reflected at metal-gas interfaces and partially reflected at metal-to-solid interfaces. Discontinuities that act as metal-gas interfaces, such as cracks, laminations, shrinkage cavities, and bonding faults, are easily detected. Inclusions and other metal inhomogeneities can also be detected by partial reflection of the sound wave. Based on this flaw detection capability, UT will provide an acceptable level of quality and safety for examining repair welds.

4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative to use GTAW ambient temperature temper bead welding for pressurizer heater sleeve nozzle weld repairs, as stated in Relief Request No. 28, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternative to the GTAW-machine temper bead welding requirements, IWA-4500 and IWA-4530 of ASME Code Section XI, at the PVNGS, Units 1 and 3 for the second 10-year ISI interval. All other requirements of the ASME Code, Section III and XI for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Contributor: D. Naujock

Date: November 3, 2004